Case Study: Parkson DynaSand D2® Filtration and Compliance

Jessy Matthew John, The Probst Group

Primarily we will be discussing DynaSand D2 Sand Filters and performance, a method of advanced tertiary filtration.

Rapid sand filters use a defined media to remove particles and impurities that have been trapped. Unfiltered water flows through the filter under gravity or pumped pressure, and material is trapped in the media matrix. Generally, filter beds are made from granular materials like: silica sand, anthracite coal, garnet sand, and granular activated carbon. The following criteria should be considered when selecting media.

- Good hydraulic characteristics (permeable bed)
- Inert and easy to clean
- Hard and durable
- Free of impurities
- Insoluble in water
- Media effective size (diameter of media particles)
- Uniformity coefficient (degree of variation in size that constitutes a granular material)

Typical Filter Media Characteristics

Material	Size Range (mm)	Uniformity Coefficient	Specific Gravity	Hardness (MOH scale)
Anthracite Coal	0.8 – 1.2	< 1.85	1.5 – 3.0	3.0
Silica Sand	0.3 – 0.6	< 1.5	> 2.5	7.0
Garnet Sand	0.2 – 0.4	< 1.5	3.8 – 4.3	7.5 – 8.0
Silica Gravel	1.0 - 50	N/A	> 2.5	7.0
GAC	0.8 – 1.2	< 2.0	1.5 – 3.0	N/A

It must be realized that porosity of the filter media does not depend on particle size, but on grading of particles. Well-graded sand, i.e., with a broader particle size distribution, will have less porosity as compared to poorly graded sand with a narrower particle size distribution. If poorly graded sand (with more porosity) is used as the filter media, the influent particles will potentially encounter a lesser number of collectors and will not be collected efficiently.

Tertiary filtration is used to reduce BOD, total suspended solids, and phosphorus in the final effluent. Suspended solids will have BOD and phosphorus associated with it. Removing suspended solids to very low levels will significantly reduce BOD and phosphorus. Filtration selects against suspended particles (silts and clays), colloidals (very small, finely divided solids that remain dispersed in a liquid due to their small size and electrical charge), biological matter (bacteria, plankton, algae), and flocculated precipitants (ferric salts and aluminum salts). Filtration may be required to consistently achieve stringent effluent limits for BOD, TSS, and phosphorus.

A DynaSand system creates a fluid media that is constantly being turned over. It is typical for DynaSand D2 filters to produce effluent TSS less than 2 mg/L or consistent turbidity less than 1.0cu. From a water quality standpoint, filter effluent turbidity will give you a good indication of overall process performance.

What are Removal Processes?

Sedimentation (gravity)

Adsorption (dissolved substance on the surface and interface zone of another material)

Biological actions (trickling filter, RBC)

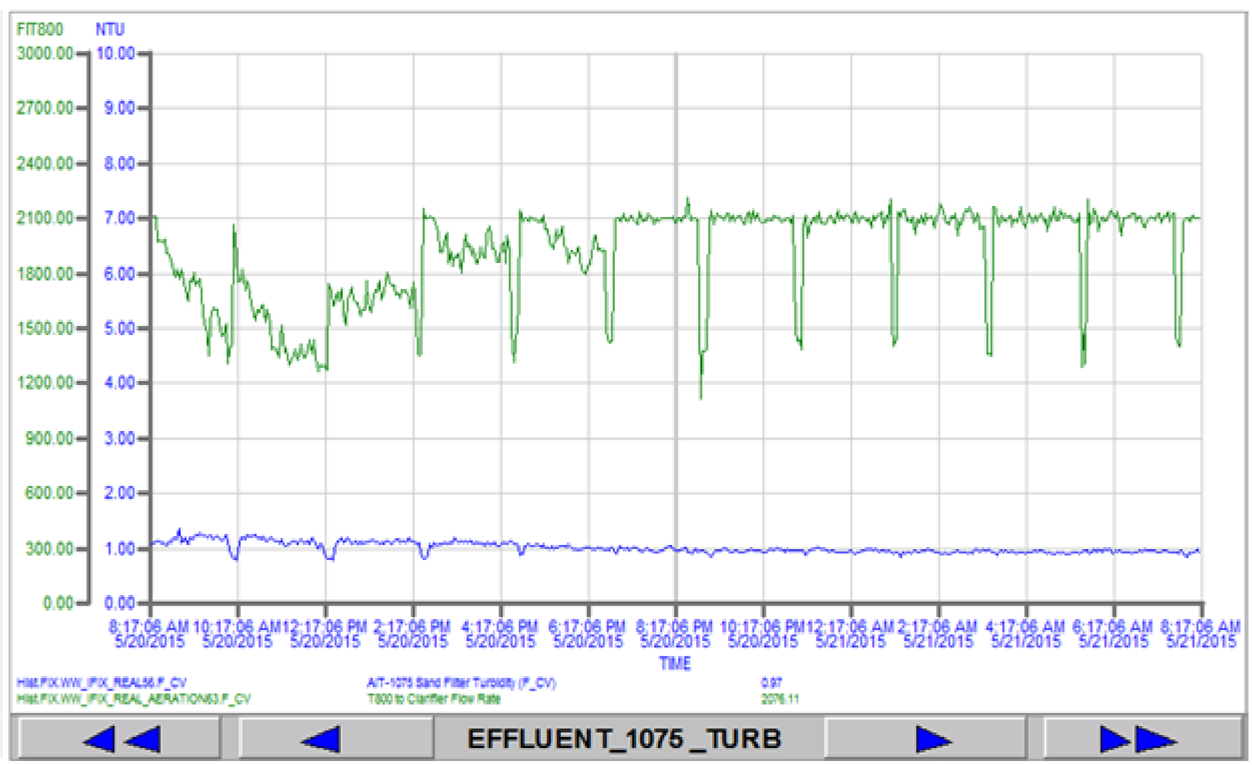
Absorption (taking in of a substance into the body of another via molecular or chemical actions)

Straining/Mechanical (removal of particulates by trapping in between the grains of the media)

What are Design Challenges and Considerations?

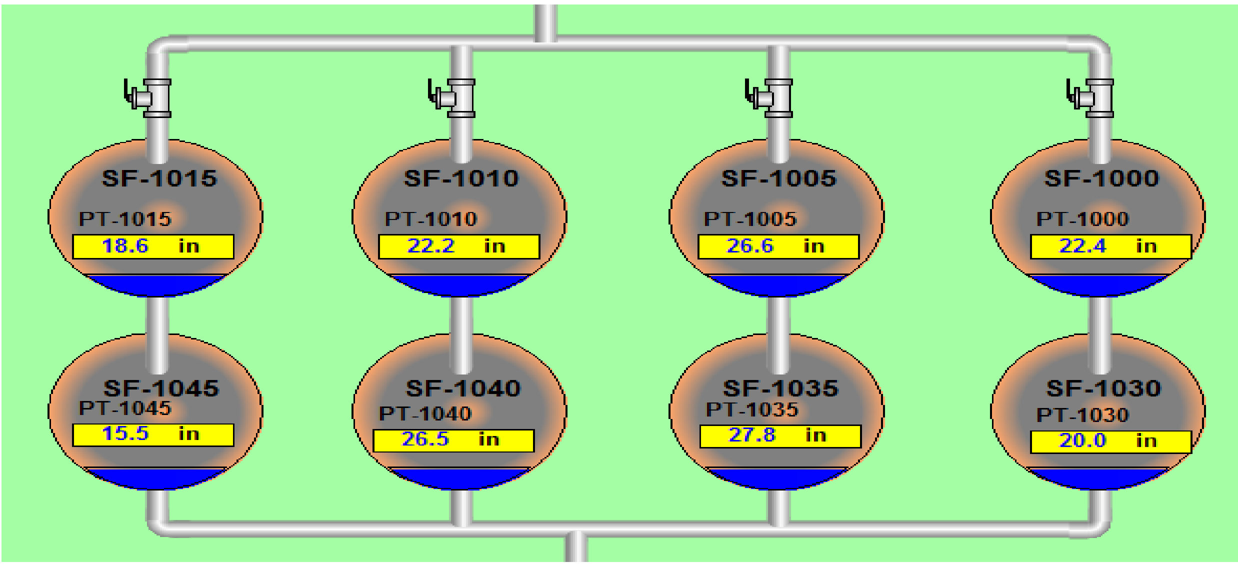
The total hydraulic design loading must consider flow across the filters and recycle side streams from backwash actions. The cross sectional filter area and number of units dictate capacity during peak flow conditions. The organic design loading to the filters will weigh solids breakthrough and terminal headloss potential. There are extended operational costs including chemical addition, electrical demand from pumps and valves, ancillary devices like air compressors, and finally environmental control conditions like humidity and temperature.

Inconsistent superficial velocity can have dramatic effects. These conditions exist with flow imbalance to filter banks, equipment issues, and even during peak flows. If pore velocity varies, the shear forces experienced by collected particles are no longer uniform. Particle detachment will likely increase and porosity of the filter bed will change dynamically, typically unfavorably. This disruption of the fluid bed has immediate negative implications as seen below.



What is Headloss and What's the Big Deal?

Headloss is defined as the loss of flow energy of the water as it passes through the filter. The greater the vertical difference between the upstream water levels and the downstream water levels, the greater the headloss. Excessively long filter runs allow accumulated organic solids trapped in the media to become anaerobic (septic) which can cause odor problems and floating organic material. Solids accumulation in the media drives headloss. Terminal headloss is the maximum headloss allowed prior to backwashing. Parkson's DynaSand® filter is a continuous backwash upflow, deep bed, granular media filter. Its unique recycling system requires no supplemental backwash pumps or storage tanks.



Q/A: Solids Breakthrough and Terminal Headloss

Increase in Filter Depth

Solids breakthrough potential will decrease since particles in water will have the opportunity to interact with more media; hence, the chance for particle attachment will increase. Terminal headloss potential increases with water encountering cumulative resistance passing through the bed.

Increase in Influent Particle Concentration

With greater particle loading rates on the filter, the rate of particle collection and, hence, the porosity of the filter bed will decrease more rapidly, leading to more rapid particle detachment and greater solids breakthrough potential. In turn, this will accelerate headloss buildup and increase terminal headloss potential.

Increase in Flocculation Strength

Particle detachment due to shear forces will become less prominent, leading to a lessened solids breakthrough potential. Since particle retention in the filter will be greater, the porosity of the filter bed will decline faster, leading to faster buildup of headloss and greater terminal headloss potential.

Increase in Media Diameter

An increase in media diameter will mean the presence of a lesser number of collectors in the filter media. This will result in fewer potential interactions between a particle and a collector; thus, solids breakthrough potential will increase. Since a lesser number of particles will be collected as mentioned above, the rate of headloss buildup will be lower and there will be a decline in terminal headloss potential.

Effect of Non-Addition of Coagulant

If no coagulants are added, the particles will be 'charge' stable and hence will not attach efficiently to other particles to promote flocculation or reduce even attachment to filter media, thus increasing solids breakthrough potential. Since the rate of particle collection in the filter media will be lower as described above, the rate of headloss buildup will also be lower, leading to a decline in terminal headloss potential.

Backwashing, Indicators, and Maintenance

Continuous/Eco Wash

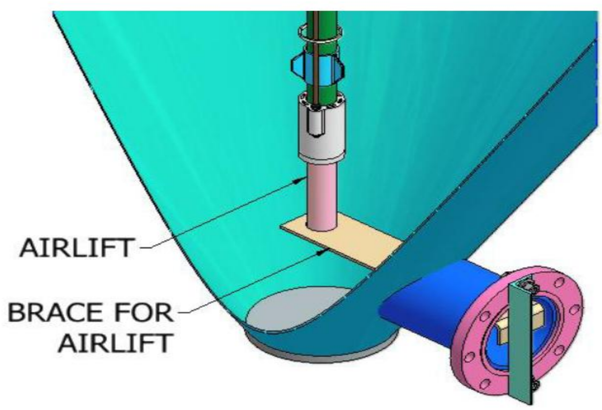
Backwashing at too high a rate is just as destructive as too low a backwash rate. On one hand, a low reject rate could freeze a fluid bed with solids, septicity, or impede sand movement. Too high of a rate could promote solids breakthrough, erode tank surfaces, damage equipment, and introduce too much reject/solid flow to the headworks.

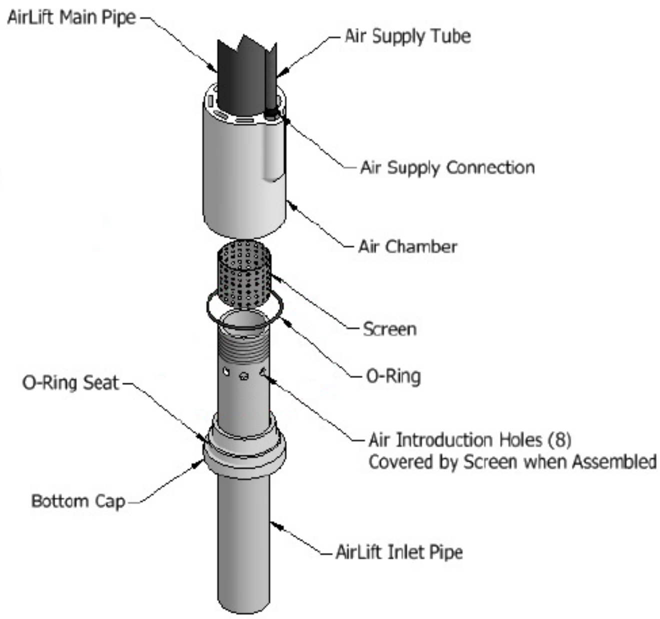
Process Issues and Indicators

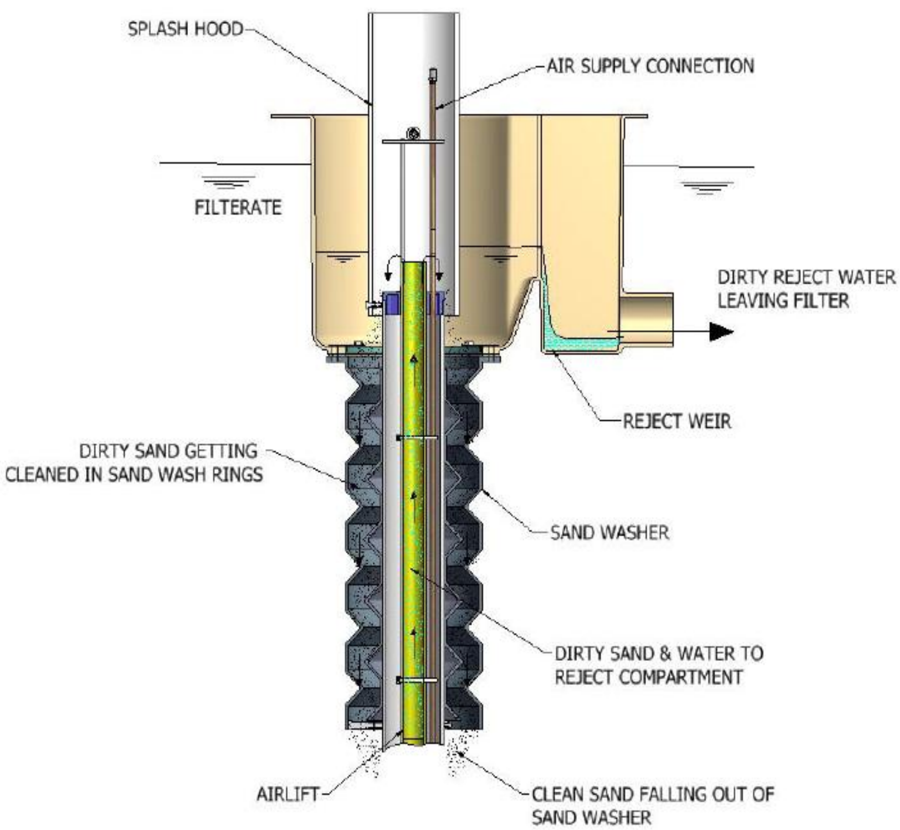
- Mudballing
- Fines and impurities
- Mineralization and pH effects on effluent, media and equipment
- Polymer and fluid bed packing
- Fissures, pockets, and channeling
- Bio solids and air entrainment
- Slime and fouling
- Chemical interactions and wear
- Flow balancing and surging
- Air Dryers: oil and moisture in compressor lines

Maintenance

- Air lift
- Air Hoses
- Reject bowl and washing
- Side walls
- Sensors and electrical
- Flooding and capacity
- Safety and fallen objects
- Filter out of service vs Service while running
- Weir plates, sizing, and reject rates




AirLift Main Pipe
Air Supply Tube
Air Supply Connection
Air Chamber
Screen
O-Ring
O-Ring Seat
Air Introduction Holes (8)
Covered by Screen when Assembled
Bottom Cap
AirLift Inlet Pipe

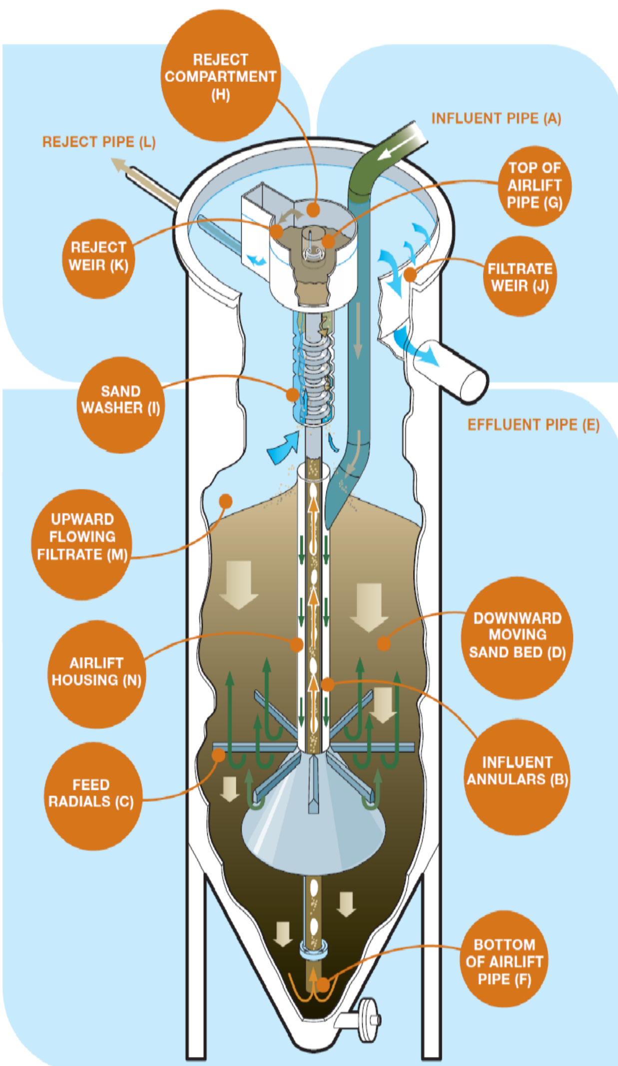

SPLASH HOOD
AIR SUPPLY CONNECTION
FILTERATE
DIRTY REJECT WATER
LEAVING FILTER
REJECT WEIR
DIRTY SAND GETTING
CLEANED IN SAND WASH RINGS
SAND WASHER
DIRTY SAND & WATER TO
REJECT COMPARTMENT
AIRLIFT
CLEAN SAND FALLING OUT OF
SAND WASHER

DynaSand D2

The Parkson DynaSand® Filter is a unique system that filters liquid suspensions to the designed effluent quality, while at the same time cleaning the sand bed so the filter is not shut down during the backwash time. Feed water is passed upwards through the sand bed and exits the top of the filter as clean water. At the same time, sand can be removed from the bottom, cleaned and returned to the top. A small portion of the filtered water is used to wash the sand and leaves the filter as a reject stream.

The DynaSand® EcoWash® Filter allows continuous filtration with intermittent sand washing. Operating in this mode, the system reduces the amount of reject water, increases filter performance, maximizes the airlift lifecycle, and reduces maintenance time.

Units are constructed fiber-reinforced plastic (FRP) (or fiber-reinforced polymer). Internal components are fabricated of stainless steel (SS) and FRP. Filters are available in a 40” standard bed design or an 80” deep-bed design or combination thereof.



DynaSand® Filter Principles of Operation

Influent Filtration

Influent feed is introduced at the top of the filter (A) and flows downward through an annular section (B) between the influent feed pipe and airlift housing. The feed is introduced into the bottom of the sand bed through a series of feed radials (C) that are open at the bottom. As the influent flows upward (M) through the downward moving sand bed (D), organic and inorganic impurities are captured by the sand. The clean, polished filtrate continues to move upward and exits at the top of the filter over the filtrate weir (J) and out through the effluent pipe (E).

Sand Cleaning

The sand bed containing captured impurities is drawn downward into the center of the filter where the airlift pipe (F) is located. A small volume of compressed air is introduced at the bottom of the airlift, drawing the sand into the airlift pipe. The sand is scoured within the airlift pipe at an intensity of 100-150 SCFM/ft2. The effectiveness of this scouring process is vastly greater than what can be expected in conventional sand filtration backwash. The scouring dislodges any solid particles attached to the sand grains.

The dirty slurry is pushed to the top of the airlift (G) and into the reject compartment (H). From the reject compartment, the sand falls into the sand washer (I) and the lighter reject solids are carried over the reject weir (K) and out the reject pipe (L). As the sand cascades down through the concentric stages of the washer, it encounters a small amount of polished filtrate moving upward, driven by the difference in water level between the filtrate pool and the reject weir. The heavier, coarser sand grains fall through this small countercurrent flow while the remaining contaminants are carried back up to the reject compartment. The clean, recycled sand is deposited on the top of the sand bed where it once again begins the influent cleaning process and its eventual migration to the bottom of the filter.

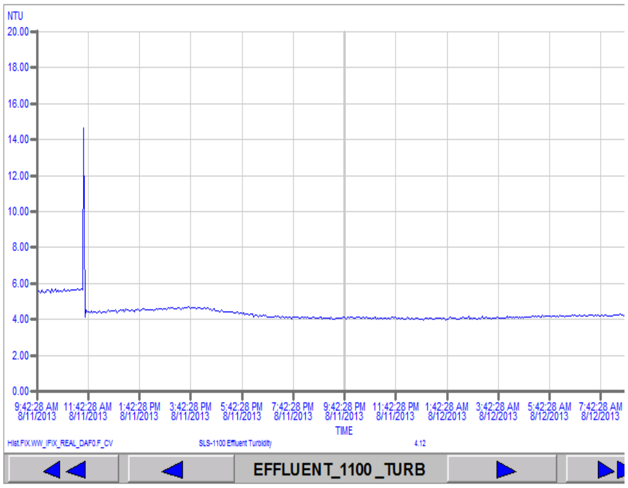
DynaSand® Features and Benefits

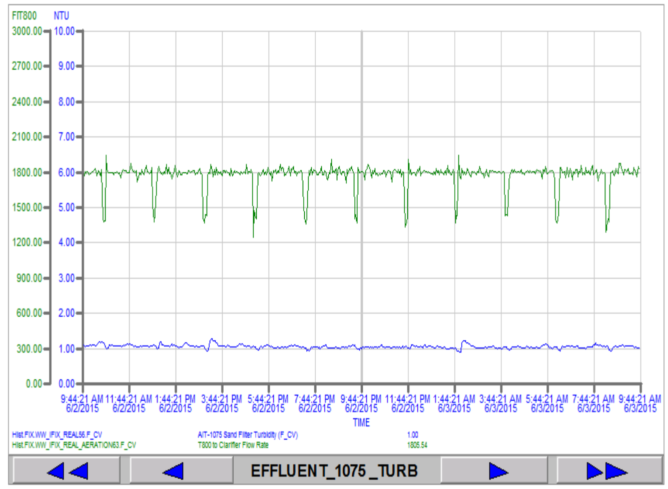
- Continuous backwash
- No underdrains or screens
- Sand washed with filtrate and done internally
- No level control
- Low power requirements
- Sand movement verification system
- Reject water reduction process control
- No moving parts
- Low pressure drop
- High solids capacity
- Single media
- Minimal maintenance and operator attention

DynaSand® EcoWash® Benefits

- Intermittent backwash: Reduces reject production by 60-90% and reduces energy requirements by 60-90%
- Better performance – increased filtrate quality
- Increases airlift life
- Reduces maintenance on air compressor system
- Reduces pretreatment chemical usage

Ultra Low Phosphorus and TSS Compliance





2013				2014				2015			
	Month	6M Avg	Limit		Month	6M Avg	Limit		Month	6M Avg	Limit
Jan-13	0.26			Jan-14	0.07	0.14	0.5	Jan-15	0.04	0.04	0.075
Feb-13	0.37			Feb-14	0.10	0.14	0.5	Feb-15	0.05	0.04	0.075
Mar-13	0.28	0.85	0.5	Mar-14	0.09	0.12	0.2	Mar-15	0.05	0.04	0.075
Apr-13	0.64	0.85	0.5	Apr-14	0.09	0.12	0.2	Apr-15	0.03	0.04	0.075
May-13	0.87	0.85	0.5	May-14	0.21	0.12	0.2	May-15	0.03	0.04	0.075
Jun-13	2.35	0.85	0.5	Jun-14	0.10	0.12	0.2				
Jul-13	0.42	0.85	0.5	Jul-14	0.12	0.12	0.2				
Aug-13	0.52	0.85	0.5	Aug-14	0.11	0.11	0.2				
Sep-13	0.16	0.14	0.5	Sep-14	0.07	0.11	0.2				
Oct-13	0.19	0.14	0.5	Oct-14	0.02	0.11	0.2				
Nov-13	0.12	0.14	0.5	Nov-14	0.04	0.11	0.2				
Dec-13	0.21	0.14	0.5	Dec-14	0.28	0.11	0.2				

	Month	Monthly Avg. Permit Limit based on 1.2 mgd		Month	Monthly Avg. Permit Limit based on 1.2 mgd		Month	Monthly Avg. Permit Limit April - Sept.
BOD Limits	0.200	<21.3	TSS Limits	0.2	<21.7	Ammonia Limits	0.041	<10